The Faint Young Sun Paradox

When the Earth was young, the sun was dimmer (25% less energy output), but the Earth's average temp was above freezing.

As the Sun increased in brightness, the average temperature of the Earth did not significantly increase.

How is this possible?
The Earth must regulate its climate somehow.
This must involve changes in the atmosphere over time.
James Lovelock
The Gaia Hypothesis

The Earth acts as a “superorganism” maintaining a climate homeostasis.

Lovelock is an atmospheric chemist who first proposed that the Earth must have complex feedbacks between the geosphere, biosphere, hydrosphere, and atmosphere that function to maintain a stable climate.

Carbon – the key to understanding how the Earth regulates its climate

And the basis for all life as we know it.

The 4th most abundant element in the universe.

Atmosphere

- Nitrogen 78%
- Oxygen 21%
- Argon 1%
- Water vapor
- Carbon dioxide
- Methane (CH₄)
- Greenhouse gases
Carbon dioxide is the most important greenhouse gas controlling climate

- it has a long residence time in the atmosphere (thousands of years).
- it is an efficient absorber of infrared radiation
- it enters and leaves the atmosphere through a variety of pathways
Where do you find carbon in Earth’s systems?

- Carbon Reservoirs – sources of carbon.
- Carbon Sinks – places where carbon is sequestered for long periods of time.
- Carbon exchanges – pathways by which carbon moves from one reservoir to another.

Where do you find carbon in Earth’s systems?

Atmosphere – CO$_2$ and CH$_4$ gas.
Hydrosphere – HCO$_3^-$ – bicarbonate ion.
Lithosphere – CaCO$_3$ – limestone rock, fossil fuel
Biosphere – C$_6$H$_{12}$O$_6$ – organic molecules.

How does carbon move from system to system? How does it enter and exit the atmosphere? – The Carbon Cycle
There are actually two related carbon cycles

- **Organic carbon cycle** – transfer of carbon mediated by living organisms. Short time scale (years to centuries).
- **Inorganic carbon cycle** – movement of carbon through atmosphere, hydrosphere, and geosphere. Long time scale (millennia to millions of years).

**Questions for Discussion**

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<tr>
<th>How do plants interact with CO₂?</th>
<th>How do animals interact with CO₂?</th>
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<th>What happens to organic material when organisms die?</th>
<th>What is the origin of coal, oil, and natural gas (fossil fuels)?</th>
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Global Flows of Carbon
(Petagrams of Carbon/Year)

* Deforestation contributes between 1 - 2

What human activities have an impact on the flow of carbon through the organic carbon cycle?

Global Flows of Carbon
(Petagrams of Carbon/Year)

* Deforestation contributes between 1 - 2